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Guiding people along more intuitive indoor paths

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Abstract: For many people navigation in the indoor environment is a challenging task. Improving indoor navigation systems could ease the wayfinding task in this environment. However, the supporting route planning algorithms in these navigation systems are currently limited to shortest path algorithms (or derivatives). The development of cognitive route planning algorithms will improve indoor navigation systems by guiding people along more intuitive and easier-to-follow paths. The development of such algorithms entails the identification of those more intuitive path characteristics in the indoor environments. To define relevant path characteristics of the indoor environment a user study is enrolled: an in-depth discussion with a focus group of experts is followed by an online survey. Focussing on user requirements in the initial phase guarantees the quality of the end products, the cognitive route planning algorithms.

Keywords: Cognition, Indoor wayfinding, Route planning algorithm, User requirements

1. Introduction

As long as people need to decide where to go and how to reach a destination, navigation will remain one of the fundamental problems in human cognition, wayfinding and geospatial research. Wayfinding is the goal-directed part of navigation based on decision making and planning and influenced by both personal and environmental factors (Montello 2005). The improvement of indoor navigation systems could ease the wayfinding task in the indoor environment.

Route planning is a key element of navigation guidance applications as it aims at computing an optimal route between a starting and a destination point (Montello 2005). Route planning algorithms in existing (indoor) navigation applications are limited to the shortest or fastest path (Vanclooster et al. 2014). However, studies have proven that people do not always prefer the shortest or fastest route to reach their destination (Golledge 1999). More intuitive and easier-to-follow routes reduce the risk of getting lost, require a smaller wayfinding effort, guide in recalling routes and are overall perceived as more comfortable (Vanclooster et al. 2014). These cognitive paths are more intuitive for the user since they are in line with the user's mental structure and thus adhere better to natural human wayfinding behaviour. This research focuses on developing cognitive route planning algorithms to guide people along more intuitive paths in an indoor environment.

Until now, little research has been devoted to the definition of indoor path characteristics that differentiate a more intuitive path from the common indoor shortest or fastest path. In order to create these cognitive indoor routing algorithms, it is crucial to understand the determining characteristics of path selection and to interpret how wayfinders make route choices in indoor environments. In other words, this research wants to focus on identifying the path characteristics people use during indoor wayfinding. The outcome of this research provides essential insights into users' natural route planning behaviour in indoor environments.

2. Methodology

To determine path characteristics of cognitive routes in indoor environments, a research design was developed in line with previous studies about outdoor navigation, route choice criteria and their accompanying path characteristics (such as intersection complexity, visibility, turning points) (e.g. Dalton 2003; Golledge 1995; Hillier and Iida 2005; Hochmair 2005). Furthermore, the research design was based on existing research on indoor wayfinding behaviour (Hölscher et al. 2006) and usability engineering and User Centred Design (UCD) (e.g. Haklay and Nivala 2010; Nielsen 1994; van Elzakker and Wealands 2007).

To obtain a well-founded and coherent selection of relevant cognitive path characteristics and to incorporate the definition of the user requirements into the design process, the first stage of the UCD-lifecycle of Nielsen (1994), a focus group and an online survey are employed.

The focus group (12 participants) is composed of diverse academic researchers and experts experienced with indoor environments, navigation and human behaviour studies. This focus group helps to define and formulate, through multiple discussions, possible cognitive path characteristics in indoor environments. Hereafter, the results of the focus group discussions are scrutinized through an online survey, in which a large group and diverse range of participants can be reached.

In the online survey, different routes in various indoor environments are recorded and displayed to the participants. Subsequently, in a questionnaire participants are asked to answer questions about these routes, their characteristics and preferences. General demographic information and characteristics (e.g. age, sex, "geographical" education, familiarity with the building) of each participant is collected as well. A group of participants is recruited as a valid sample of the "general public" that is diverse enough with respect to their personal characteristics and large enough so that a robust statistical analysis can be applied to the survey data.

Communication with potential users of indoor navigation systems, both with and without expertise, in an early stage in the project has two advantages. First, participants get closely involved in the project as they can follow its progress from the initial stage. Second, obtaining user input at the beginning of novel research is vital to obtain a final result that is keyed to the end user's need: early input can easily be integrated in the subsequent steps. This is conform with the User-Centered Design (UCD) approach of Nielsen (1994), which has proven its value to create usable end results (e.g. Nielsen 1994).

Integrating the results of the focus group and the online survey leads to a coherent selection of relevant cognitive path characteristics and provides complementary information on the main path characteristics in the indoor environment. Through this combination of qualitative and quantitative research, the path characteristics that differentiate a more intuitive path from the currently used indoor shortest or fastest paths (e.g. Kwan and Lee 2005; Thill et al. 2011) are defined.

3. Conclusions and Future Work

In general, the results of this research will provide essential knowledge on which characteristics are determinative in human path selection in indoor environments and how humans interpret these path characteristics. The outcome of this research is twofold. Not only will information be collected on how to make users more comfortable during their route planning tasks in an indoor environment, but also will this research contribute to the overall understanding of indoor wayfinding and navigation.

The obtained path characteristics will be incorporated in the cognitive route planning algorithms. The development of such algorithms requires a theoretical conceptualization of the underlying spatial concepts of each of those path characteristics, which have to model the users' perception on these path characteristics. The underlying indoor spatial

model has to be taken into account in this process, as this determines the structure of the algorithm and could influence the results and accuracy of the algorithmic implementation (Vanclooster, Van de Weghe, et al. 2014).

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References

Dalton, R. C. (2003). The Secret Is To Follow Your Nose. *Environment and Behavior*, *35*(1), 107–131. doi:10.1177/0013916502238867

Golledge, R. G. (1995). Path selection and route preference in human navigation: A progress report. In A. U. Frank & W. Kuhn (Eds.), *Spatial Information Theory A Theoretical Basis for GIS* (Vol. 988, pp. 207–222). Springer Berlin Heidelberg. doi:10.1007/3-540-60392-1_14

Golledge, R. G. (Ed.). (1999). *Wayfinding Behavior: Cognitive Mapping and Other Spatial Processes*. Baltimore and London: Johns Hopkins University Press.

Haklay, M. M., & Nivala, A.-M. (2010). User-Centred Design. In M. M. Haklay (Ed.), *Interacting with Geospatial Technologies* (pp. 89–106). John Wiley & Sons, Ltd. doi:10.1002/9780470689813.ch5

Hillier, B., & Iida, S. (2005). Network and psychological effects: a theory of urban movement. In A. G. Cohn & D. M. Mark (Eds.), *Spatial Information Theory* (pp. 475–490). Springer-Verlag Berlin Heidelberg. papers2://publication/uuid/51712050-C088-4BAE-B7A0-6A4372B28C46

Hochmair, H. (2005). Towards a Classification of Route Selection Criteria for Route Planning Tools. In P. F. Fisher (Ed.), *Developments in Spatial Data Handling* (pp. 481–492). Springer Berlin Heidelberg. http://dx.doi.org/10.1007/3-540-26772-7_37

Hölscher, C., Vrachliotis, G., & Meilinger, T. (2006). The floor strategy: wayfinding cognition in a multi-level building. In *Proceedings of 5th International Space Syntax Symposium* (Vol. 2, pp. 823–824). Delft, Netherlands: Techne Press. http://www.spacesyntax.tudelft.nl/media/Papers/212sp.pdf

Kwan, M. P., & Lee, J. (2005). Emergency response after 9/11: The potential of real-time 3D GIS for quick emergency response in micro-spatial environments. *Computers, Environment and Urban Systems*, *29*(2), 93–113. doi:10.1016/j.compenvurbsys.2003.08.002

Montello, D. R. (2005). Navigation. In P. Shah & A. Miyake (Eds.), *The Cambridge Handbook of Visuospatial Thinking* (pp. 257–294). Cambridge: Cambridge University Press. doi:10.1017/CBO9780511610448

Nielsen, J. (1994). *Usability Engineering*. San Francisco, CA, USA: Morgan Kaufmann Publishers Inc.

Thill, J. C., Dao, T. H. D., & Zhou, Y. (2011). Traveling in the three-dimensional city: Applications in route planning, accessibility assessment, location analysis and beyond. *Journal of Transport Geography*, *19*(3), 405–421. doi:10.1016/j.jtrangeo.2010.11.007

van Elzakker, C. P. J. M., & Wealands, K. (2007). Use and users of multimedia cartography. In W. Cartwright, M. P. Peterson, & D. G. Gartner (Eds.), *Multimedia cartography* (pp. 487–504). Springer Berlin Heidelberg.

Vanclooster, A., Ooms, K., Viaene, P., Fack, V., Van De Weghe, N., & De Maeyer, P. (2014). Evaluating suitability of the least risk path algorithm to support cognitive wayfinding in indoor spaces : an empirical Evaluating suitab. *Applied Geography*, *53*, 128–140.

Vanclooster, A., Van de Weghe, N., Fack, V., & De Maeyer, P. (2014). Comparing indoor and outdoor network models for automatically calculating turns. *Journal of Location Based Services*, *8*(3), 1–18. doi:10.1080/17489725.2014.975289